THE ANATOMY OF *HYLA CÆRULEA* WHITE.

I.—The Pectoral Girdle and Vertebral Column.

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(With Ten Text Figures).

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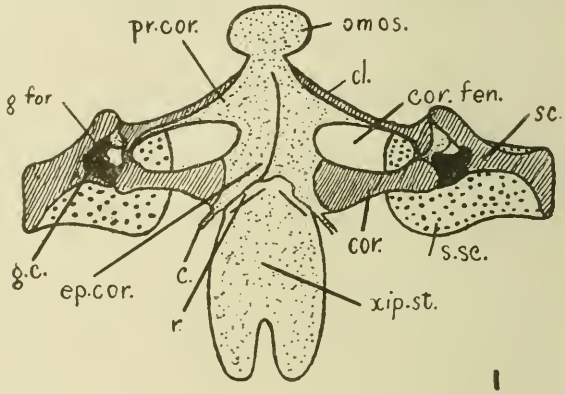
The Pectoral Girdle.

The pectoral girdle of *Hyla cærulea* White, is described and figured by W. K. Parker* under the name *Calamites cyanea* Fitzinger. In the specimens examined by us we found that they exhibited a number of features differing from Parker's work. F. E. Beddard (1) states that it is probable that some of the species described by Parker in his "Monograph" have been incorrectly identified. The acceptance of this view may explain the differences observed by us.

The pectoral girdle of *Hyla cærulea* White (Fig. 1) is of the Arciferous type, in which the epicoracoids are not united in the mid-line ventrally, and the right portion of the girdle overlaps the left, when the girdle is examined from the ventral surface. Out of twenty-three specimens, four were abnormal in having the left portion of the girdle overlapping the right. This means that the frequency of the occurrence of the abnormality is about 17 per cent. in this particular case. We are of the opinion, however, that this percentage is rather higher than the average.

*"Monograph of the Shoulder Girdle," p. 76, pl. vii., fig. 6.

The coracoids (Figs. 1 and 2, *cor.*) are stout bones, expanded at the ends. They run posteriorly inwards, and their inner extremities are fused with the paired cartilaginous epicoracoids (Fig. 1, *ep. cor.*) The anterior and posterior borders of each coracoid are concave. A coracoid is divided into two regions, a proximal and a distal, of which the latter is the larger and is fan-shaped or dilated. The epicoracoids are flattened plates which pass forwards and become continuous with the procoracoids (Fig. 1, *pr. cor*). The outer margin of each epicoracoid



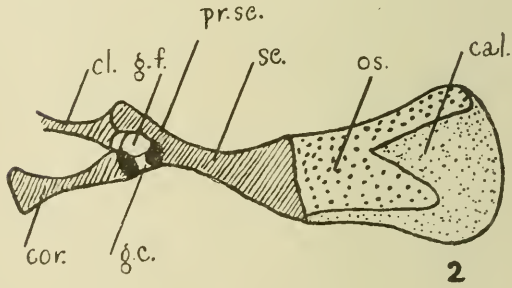


Fig. 1—Ventral view of pectoral girdle (enlarged nearly twice).

Fig. 2—Ventral view of scapula and suprascapula drawn stretched out (x 2).

c. cornu at junction of coracoid and epicoracoid; *cal.* cartilaginous portion of suprascapula; *cl.* clavicle; *cor.* coracoid; *cor. fen.* coracoidal fenestra; *ep. cor.* epicoracoid; *g.c.* glenoid cavity; *g.f., g. for.* glenoid foramen; *omos.* omosternum; *os.* ossified region of suprascapula; *pr. cor.* procoracoid; *pr. sc.* prescapular process; *r.* transverse ridge on xiphisternum; *sc.* scapula; *s. sc.* suprascapula; *xip. st.* xiphisternum.

is convex, and near the junction with the corresponding coracoid is a slender cartilaginous cornu (Fig. 1, *c.*), which travels posteriorly to the body wall. The procoracoids are paired cartilaginous bars, running from the anterior ends of the epicoracoids to the glenoid regions of the girdle (Figs. 1 and 2, *g.c.*) In the triangle formed by the coracoid, epicoracoid and procoracoid of each side, is the coracoidal fenestra (Fig. 1, *cor. fen*), which is oval in shape. The clavicles (Figs. 1 and 2, *cl.*) are paired and ossified. They are curved, with the concavity facing anteriorly, and almost completely invest the procoracoids, but the posterior borders of the latter are uncovered. On each side the glenoid cavity (Figs. 1 and 2, *g.c.*) is formed by the coracoid, scapula, clavicle, and procoracoid. The scapula (Fig. 2) is similar to that figured by Parker. In the glenoid region the scapula is bifid, and the prescapular process (Fig. 2, *pr. sc.*) is the longer of the two portions. Between the latter lies the glenoidal foramen (Fig. 1 and 2, *g. for.*, *g.f.*). The distal border of the scapula is straight, and the anterior and posterior are concave. The suprascapula (Fig. 1, *s. sc.*), is attached to the distal border of the scapula (Fig. 2). It is four-sided, and lies dorsally. Parker described the anterior border as being convex, and draws attention to the statement. We found that both the anterior and posterior borders are concave. Part of the suprascapula is ossified (Fig. 2, *os.*), but the remainder is cartilaginous (Fig. 2, *cal.*) The ossified region arises along the scapula-suprascapular junction. Distally it is bifid. The anterior arm is more or less uniform in width, while the posterior is somewhat triangular in most examples. The anterior border of the suprascapula is ossified, but the posterior and distal are cartilaginous.

The omosternum of Parker's *Calamites cyanea* is "shark tooth shaped," to use his words, and furnished with an "ectosteal crown." At the base are two soft diverging fangs or processes. We find that the omosternum is a cartilaginous oval or circular plate (Fig. 1, *omos*). Beddard states that the sternum of *Hyla cærulea* exactly resembles that of Parker's *Acrodytes daudinii* (? a Hyla). The omosterna examined by us resemble that figured for the latter (pl. vii., Fig. 1), but the long axis in the oval

forms is transverse and not vertical or parallel to the long axis of the animal. The omosternum is situated anteriorly to the epicoracoids, and unites the two pectoral components in this region. On tearing the girdle components apart, the omosternum divides into two—each part remaining attached to its corresponding epicoracoid. There is a constriction between the omosternum and the epicoracoids. The xiphisternum (Fig. 1, *xip. st.*) is a flattened cartilaginous plate with two posteriorly directed cornua. We find that they are not so slender as figured by Parker for *Calamites cyanea*, neither are they so stout as those of his *Acrodytes daudinii*, the form Beddard (1) says *Hyla caerulea* exactly resembles in regard to the sternum. The condition observed by us is intermediate between the two. In our specimens the outer border is convex, while in *Calamites cyanea* it is straight. Each cornu is thickened in the mid-longitudinal line. Arising on each side of the ventral mid-line of the anterior undivided portion of the xiphisternum is a transverse ridge (Fig. 1, *r.*) running a little posteriorly. These two ridges are ventral to the epicoracoids and overlap their posterior edges. Anteriorly, an oblique median septum separates the two compartments formed by the transverse ridges. The xiphisternum is connected to the pectoral arch by connective tissue. The sterno-hyoid muscle arises as two strands from the dorsal surfaces of the xiphisternal cornua—a strand from each cornu. The fibres pass anteriorly, and are inserted into the body of the hyoid.

Vertebral Column.

The vertebral column (Fig. 3) consists of the typical Anuran components, viz. :—nine vertebræ including the atlas, and a urostyle or os coccygeum. *Hyla cærulea* agrees with the other species of *Hylidæ* in having the sacral transverse processes or diapophyses expanded. The transverse processes of the vertebræ fall into two groups in regard to size. Those of the second, third, fourth and ninth are well developed, while those of the fifth, sixth, seventh and eighth are comparatively slender. In the second-eighth vertebræ the posterior notches in the pedicles, forming the anterior portions of the inter-vertebral foramina, are larger than the anterior ones. The anterior

and posterior zygapophyses are well developed in the third-eighth (Fig. 7). On the posterior border of each diapophysis of the third, is a small prominence, which in extreme cases was very poorly developed on either one or both processes.

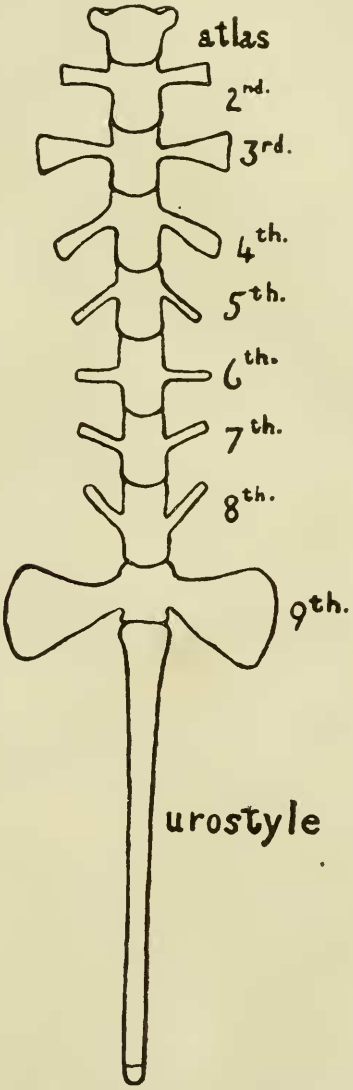


Fig. 3—Vertebral column (ventral view).

Atlas (Fig. 4, A, B.) On the dorsal surface is a neural spine, represented by a median longitudinal ridge, which is more strongly developed posteriorly. The anterior edge of the neural arch is notched slightly in the mid-line dorsally. The posterior zygapophyses are small, and the anterior are absent. The posterior articular face of the centrum is strongly flattened dorso-ventrally. Posterior notches in the pedicles are present for the anterior portions of the first intervertebral foramina, but there are no anterior ones.

Second vertebra (Fig. 5). The transverse processes are horizontal and well-developed. The posterior zygapophyses are normal, but the anterior are small, in agreement with the small size of the posterior processes of the atlas. The neural spine is comparatively prominent and projects in front. Posteriorly, ridges are given off from it to the posterior zygapophyses.

Third vertebra (Fig. 6). The transverse processes are very well developed, being next in size to those of the ninth or sacral vertebra. In the vertical plane the transverse processes make an angle of 90 degrees with the longitudinal axis of the centrum, but in the horizontal plane they are directed ventrally at an angle of about 20 degrees. The neural spine is comparatively well developed, like that of the second, but projects posteriorly.

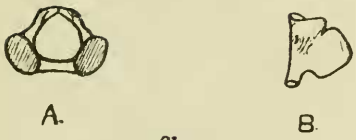
Fourth vertebra. The transverse processes are well developed, and directed posteriorly.

Fifth vertebra (Fig. 7). The transverse processes are slender and directed posteriorly like the former.

Sixth vertebra. In the sixth the transverse processes are slender but horizontal.

Seventh vertebra. The only difference of importance between this vertebra, and the sixth is that in the former the transverse processes project anteriorly.

Eighth vertebra. The transverse processes are similar to those of the seventh, but they approach the vertical more closely than the latter. Nicholls (7) draws attention to a statement of Gadow (2) in which the latter remarks that the eighth vertebra is bi-concave in the procœlous families of Anura. Nicholls shows that this is incorrect,



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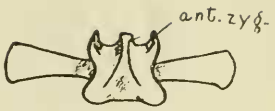

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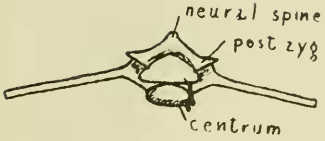

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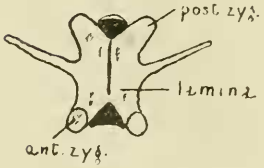

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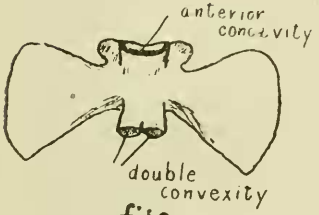

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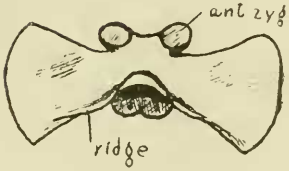

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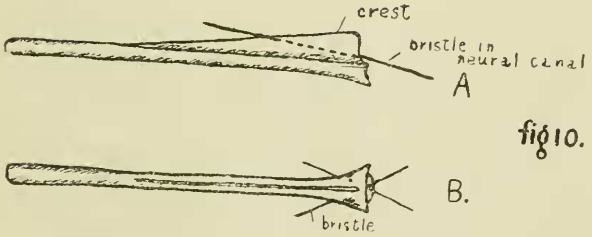

fig10.

Fig. 4—Atlas A. anterior view.
B. side view.

Fig. 5—2nd vertebra, dorsal view.

Fig. 6—3rd vertebra, posterior view.
post zyg.=posterior zygapophysis.

Fig. 7—5th vertebra, dorsal view.
ant. zyg.=anterior zygapophysis.

Fig. 8—9th vertebra, ventral view.

Fig. 9—9th vertebra, dorsal view.

Fig. 10—Urostyle. A. side view with bristle showing course of neural canal. B. dorsal view, with bristles indicating position of 10th foramina. (Figs. 4-10 enlarged $2\frac{1}{3}$ times).

for all the vertebræ are procœlous in the *Hylidæ*, *Bufonidæ* and *Cystignathidæ* examined by him. He made observations on eighteen species of *Hylidæ*, including two specimens of *Hyla cærulea*. We support his statements in regard to this form. We found that in fourteen disarticulated eighth vertebræ the centra of them all were procœlous.

Ninth or sacral vertebra (Figs. 8 and 9). The transverse processes are large and dilated, edged with cartilage. The anterior zygapophyses are well developed, but the posterior are absent. In the disarticulated specimens examined by us numbering sixteen, all the centra were procœlous, and thus we confirm Nicholls' work with reference to the sacral or ninth of *Hyla cærulea*. Immediately behind the double convexity of the posterior surface of the centrum, is a depression on its ventral aspect. The anterior notches in the pedicles are better developed than the posterior. Usually the latter, in the other vertebræ, are the more prominent. The neural spine is continuous posteriorly with a ridge, on each side, running towards the outer edge of a transverse process, in the region of the posterior border.

Urostyle (Fig. 10, A, B.) The urostyle is somewhat under half the total length of the vertebral column. It consists of a ventral cylindrical portion and a dorsal crest. The former is straight, but curves slightly ventrally in the anterior region. The articular surface is on the anterior face of the cylindrical part of the urostyle. It is oval, and bears the double concavity into which fits the double convexity of the sacral vertebra. The sides of the anterior face are concave. Anteriorly, the crest is more or less perpendicular, while the dorsal edge slopes away gradually. The anterior edge is about equal in height to the minor axis of the articular surface. The crest runs from the anterior end to about two-thirds of the length of the ossified portion of the urostyle. Posteriorly, the latter is tipped with cartilage. Apparently, the neural canal's running obliquely upwards and opening on the dorsal surface of the neural crest, is a normal feature. Seventeen complete specimens of urostyles were examined. The neural canal was present in them all. A hair or bristle passed through fifteen, from the anterior opening of the canal to the exterior on the dorsal surface. In one

specimen a hair was inserted from the dorsal opening, and passed anteriorly; it didn't travel completely through, as evidently some obstruction was present in the canal. In the remaining specimen, the latter could be seen passing from the anterior end to the crest, but while endeavouring to insert a bristle into the passage, a portion of the former broke off and became firmly wedged in the cavity. The opening of the crest is in the region of the middle third of the distance along the latter. In some urostyles the foramina of the 10th spinal nerves were observed. Apparently (*a*) both may be present: (*b*) only one, or (*c*) both may be absent.

In the examination of the urostyles (for the neural canals) and the vertebræ, the specimens first were placed in a solution of sodium hydroxide. Care had to be taken to avoid prolonged boiling, as this resulted in the destruction of the bone.

Several variations of interest were observed. In one sacral vertebra the specimen was asymmetrical; the extremity of the left transverse process (the vertebra being viewed from the ventral surface) was higher than the right, and the right tuberosity of the urostylar articulation was malformed. Another vertebra, a second, was remarkable in having the right transverse process (from the ventral surface) directed anteriorly, while the left was horizontal. One of the vertebral columns examined showed a double variation. The transverse processes of the eighth and one of the ninth were dilated or fan-shaped. The remaining one of the ninth was flattened but not dilated. Apparently the two vertebræ formed a species of double sacrum. When viewed from the ventral surface the right transverse process of the eighth was larger than the left, but the left of the ninth was larger than the right. In size, the larger of the eighth was about equal to the larger of the ninth.

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